Measuring $^{12}C+^{16}O$ for Nuclear Astrophysics

PROJECT SUPERVISION :
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Context :
Stars are astronomic objects amounts of gas (vastly hydrogen and helium) compacted and heated by its own weight. In the core of a star, the temperatures are high enough for nuclear reactions between tiny objects like the cores of atoms to take place. These processes generate heavier elements and actually all the abundance around us was synthesized in stellar processes. Fusion of two nuclei like carbon or oxygen is one of the dominating processes in stars bigger than the sun ($M > 8..10\ M_{\odot}$) in later stages of their development, notably during carbon burning. Though happening during an advanced stellar phase, only few light species of atoms like H, He, Li, C, O with a small number of possible reactions are available, and *e.g.* the $^{12}C+^{12}C$ and $^{12}C+^{16}O$ reactions happen. They are particularily efficient with high reaction probability, when cluster states are populated. Such clusters are energetically favourable and can therefore reveal themselves in resonances of the reaction probability. Clear knowledge from measurements yields valuable input for understanding the nature of stars and of the composition of the elements around us.

Project Details :
This work in the STELLA (STELlar Laboratory) group is about ultra sensitive fusion cross-section measurements for nuclear astrophysics. The team collaborates with national (IJCLab Orsay, GANIL) and international (Univ. of York (UK), Univ. of Padua (Italy)) partners and has conducted extensive high-precision measurements of the $^{12}C+^{12}C$ fusion reaction. The measurement apparatus, notably charged particle detection (DSSSD) was adapted and is currently being upgraded to match the requirements for identifying the more complex decay pattern of the $^{12}C+^{16}O$ reaction. The student will be introduced into the DSSSD system and will develop search strategies to identify the reaction channels of the $^{12}C+^{16}O$ compound. This work will be based on analysing existing $^{12}C+^{16}O$ data from a recent cross section measurement with AGATA-Sauron at LNL, Legnaro (Italy). This setup employs the same detection principle like STELLA and the similarities will be used to extract valuable information for measurements with STELLA. The subject is designed to be developed into a PhD thesis with measurements at IJCLab, analysis of coincident gamma-particle data and national/international experiments within the STELLA collaboration.

Technical Aspects/Requirements :
The student will be introduced into the analysis strategy for charged particles, the selection of the decay channels and cross-section calculation. The existing ROOT macros can be integrated into the analysis code for this internship, that needs to be developed. Geant4 simulations for efficiency calibration will be performed with the existing framework where the necessary analysis and supplementary programs based on ROOT exist. The work at a test bench at IPHC Strasbourg will be guided, but with the aim of giving the student responsibility of this working task, and might be complemented with measurements at the accelerator site at Andromède, IJCLab.

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